

IMAGE PROCESS METHOD, IMAGE PROCESS APPARATUS  
AND STORAGE MEDIUM

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to an image process method for correcting an image signal, an image process apparatus adopting the above method, and a storage medium storing a program to execute the above method.

10 More particularly, the present invention relates to an image process apparatus for decreasing a color noise, an image process apparatus adopting the above method, and a storage medium storing a program to execute the above method.

15 Related Background Art

In recent years, as hard-copy technology, especially a full-color hard-copy technology, develops, an excellent image reproduction can be achieved by using printing technology such as an inkjet recording system and the like and a high-pixel digital camera. By recording materials and image processes, color reproduction evolves up to extent by which digital photographing provides with an equal reproduction ability with silver bromide photographing.

25 However, there is a drawback that a color noise due to a characteristic of an image pickup element or the like in an input apparatus might be included in the

image itself which should be printed. For example,  
there is a drawback that a noise due to a dark current  
in a CCD element, a fixed pattern noise, a noise on a  
signal line due to color signal transmission, and the  
5 like occasionally mix with the input image.

In order to eliminate the above drawback, Japanese  
Patent Application Laid-Open No. 5-153608 (simply  
called JPA '608: corresponding to U.S. Patent No.  
5,432,869) describes that, by obtaining an average of  
10 upper and lower dye data adjacent to a notable pixel  
along the vertical direction, the dye data is subjected  
to smoothing filtering in the vertical direction  
without deteriorating image brightness.

Further, JPA '608 describes that, by detecting the  
15 correlation of the brightness of continuous three  
pixels along the vertical direction, an edge part where  
a change in the brightness along the vertical direction  
is extreme according to the correlation of the  
brightness is considered to be the part where also a  
20 change in the dye data is large, and thus the smoothing  
filtering is decreased for such the part. Conversely,  
when the change in the brightness along the vertical  
direction is small, the smoothing filtering is  
increased. Further, JPA '608 describes a method for  
25 expanding, by repeating an operation to obtain the  
above average for the notable pixel several times, the  
smoothing for the dye data along the vertical direction

with simple structure.

However, when such the conventional color noise elimination as above is applied to an image signal, apparent (or seeming) resolution of texture on the image not detected easily only by the edge from the brightness signal might be deteriorated. Further, when chromaticity of an attentional color noise is greatly different from surrounding chromaticity, there is a problem that it is necessary to repeat a color noise elimination process several times for the notable pixel.

In recent years, from the viewpoint of desirable color reproduction, an input image is first analyzed by a printer driver or the like, and processes such as brightness correction, saturation (or chroma) emphasis and the like are performed to the input image itself in accordance with the analysis result. For example, Japanese Patent Application Laid-Open No. 10-200777 describes that an image is first analyzed, and then a process for appropriate saturation correction is performed.

Further, when an image taken by a low-pixel digital camera is printed, such the printed image might be overshadowed by the printed image taken by the above high-pixel digital camera, whereupon a method of enlarging or expanding the input image to a suitable size by using anti-aliasing technique such as a bicubic

manner, a nearest neighbor manner or the like is known.

Further, the noise such as the color noise or the like due to the dark current in the CCD element is included in the digital camera image. In color reproduction based on a subtractive color mixture system used in a hard copying machine, a gray line is very unstable frequently, and gradation is occasionally reversed around the gray line. Thus, since the color which should be originally the gray replaces the color around the gray line because of a color noise, there is a problem that it becomes easy for such the reversal part as above to appear on the printed image.

As a process to reduce the color noise, a color noise reduction process to divide a video signal into a brightness signal and a color difference signal in a TV set and clip the amplitude in the frequency band corresponding to the color noise part of the color difference signal is known.

However, if the image correction processes such as the brightness correction, the saturation emphasis and the like according to the analysis result, the enlargement process and the noise reduction process are combined, following problems are caused.

Namely, since the saturation of the entire image is emphasized according to the image correction processes such as the saturation emphasis and the like, the effect of the color noise reduction process might

not be able to be demonstrated about the emphasized color noise part.

Further, since the input image is subjected to the enlargement process, the effect of the color noise reduction process might not be able to be demonstrated about the enlarged color noise part.

#### SUMMARY OF THE INVENTION

An object of the present invention is to provide an image process method capable of achieving high-level color noise reduction without deteriorating apparent (or seeming) resolution for a color signal, an image process apparatus adopting this method, and a storage medium storing a program to execute this method.

In order to achieve the above object, the present invention provides an image process method comprising: an input step of inputting color image data composed of a signal representing brightness and a signal representing tint; and a smoothing process step of performing a smoothing process to the signal representing tint, while holding the signal representing brightness.

Another object of the present invention is to be able to effectively perform a color noise reduction process, and to be able to effectively perform the color noise reduction process and an image correction process.

In order to achieve the above object, the present invention provides an image process method comprising: a calculation step of calculating a feature quantity of an input image; a color noise reduction process step of performing a color noise reduction process to input image data; and an image correction step of performing a correction process to the input image subjected to the color noise reduction process, on the basis of the calculated feature quantity.

Still another object of the present invention is to be able to effectively perform the color noise reduction process and an image scaling process.

In order to achieve the above object, the present invention provides an image process method comprising: a color noise reduction process step of performing a color noise reduction process for input digital image data; and a scaling step of scaling an image size, wherein the order of the color noise reduction process step and the scaling step is controlled in accordance with a scaling rate or a scaling method.

Other objects and features of the present invention will become apparent from the following detailed description and the attached drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram schematically showing an image process apparatus 100 according to the first

embodiment of the present invention;

Fig. 2 is a block diagram showing a printer driver  
103 in the first embodiment;

Fig. 3 is a block diagram showing an image  
5 correction process unit 120 in the first embodiment;

Fig. 4 is a flow chart showing an operation of a  
color noise reduction process which is performed by the  
image correction process unit 120 in the first  
embodiment;

10 Fig. 5 is a diagram showing an weight  
configuration of a low-pass filter;

Fig. 6 is a diagram showing a filter in which  
higher weight as compared with unprocessed signal  
values is allocated;

15 Fig. 7 is a diagram showing a filter in which high  
weight is allocated to pixels away from a notable  
pixel;

Fig. 8 is a flow chart showing an operation of the  
color noise reduction process which additionally  
20 includes edge judgment and the like;

Figs. 9A, 9B and 9C are diagrams showing weight  
configurations of the low-pass filters;

Fig. 10 is a state transition chart showing a  
process sequence in a case where a scene change  
25 judgment unit is provided, and the filter for  
processing the image is changed according to a position  
of a process target in an image;

Fig. 11 is a diagram showing how to change the filter in the case where the filter for processing the image is changed according to the position of the process target in the image;

5        Fig. 12 is a diagram showing an image data division method in a case where image data is divided and then processed;

Fig. 13 is a diagram showing a lightness correction curve in case of lightness correction;

10       Fig. 14 is a diagram showing image data subjected to a filtering process with different tint for each divided area in case of dividing the image data, and an image division method;

Fig. 15 is a flow chart showing a suitable process procedure for each process in the first embodiment;

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Fig. 16 is a flow chart showing a suitable process procedure for each process in the second embodiment;

Fig. 17 is a flow chart showing a suitable process procedure for each process in the third embodiment;

20       Fig. 18 is a diagram showing an example of a brightness histogram in a non-natural image such as a computer graphics (CG) image; and

Figs. 19A, 19B and 19C are diagrams showing an example of a brightness correction curve determination method.

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## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

### [First Embodiment]

Fig. 1 is a block diagram schematically showing an image process apparatus 100 according to the first  
5 embodiment of the present invention.

For example, a printer 106 such as an inkjet printer or the like and a monitor 105 are connected to the image process apparatus 100 which includes a host computer.

10 The image process apparatus 100 includes, as software, applications 101 such as a word processor, a spreadsheet program, an Internet browser and the like, an OS (operating system) 102, a printer driver 103 which processes a group of various drawing instructions  
15 (an image drawing instruction, a text drawing instruction and a graphics drawing instruction) indicating output images issued to the OS 102 according to the applications and creates printing data, and a monitor driver 104 which processes the group of various  
20 drawing instructions and displays them on the monitor 105.

Further, the image process apparatus 100 includes, as various hardware which can execute the above software, a CPU (central process unit) 108, an HD (hard  
25 disk driver) 107, a RAM (random-access memory) 109, a ROM (read-only memory) 110, and the like.

As for the image process apparatus 100, for

example, an apparatus which uses Windows 95 (TM) of  
Microsoft Corporation as the OS for a widespread  
personal computer of AT compatible machine of IBM  
Corporation and in which arbitrary printable  
5 applications have been installed is thought.

In the image process apparatus 100, text data  
classified to text such as a character or the like,  
graphics data classified to graphics such as a figure  
or the like, and image data classified to a natural  
10 image or the like which are all created by the  
application 101 are converted into output image data.

When the output image data is printed and output,  
a printing output request is issued from the  
application 101 to the OS 102. By the application 101,  
15 the graphics drawing instruction is issued to the OS  
102 for the graphic data part, and a group of image  
drawing instructions indicating the output image is  
issued to the OS 102 for the image data part.

The output request from the application 101 is  
20 received by the OS 102, and the group of drawing  
instructions is thus issued to the printer driver 103  
corresponding to the printer 106. The printing request  
and the group of drawing instructions input from the OS  
102 are processed by the printer driver 103, the output  
25 image data capable of being printed at the printer 106  
is created and then transferred to the printer 106.

When the printer 106 is a raster printer, in the

printer driver 103, an image correction process is performed sequentially to the drawing instructions issued from the OS 102, and the processed drawing instructions are sequentially rasterized to an RGB (red, green and blue) 24-bit page memory. After all the drawing instructions are rasterized, the content of the RGB 24-bit page memory is converted into a data format printable by the printer 106 such as C (cyan), M (magenta), Y (yellow) and K (black) data, and the converted data is then transferred to the printer 106.

Next, the process operation of the printer driver 103 in the present embodiment will be explained.

Fig. 2 is a block diagram showing the printer driver 103 in the present embodiment.

The printer driver 103 is composed of an image correction process unit 120 and a correction process unit for the printer (hereinafter called a printer correction process unit) 121.

By the image correction process unit 120, an image correction process is performed to color information included in the group of drawing instructions input from the OS 102. In this image correction process, a color noise reduction process is performed based on the R, G and B color information.

In the printer correction process unit 121, the drawing instructions are first rasterized based on the color information subjected to the image correction

process, and a raster image is formed on the RGB 24-bit page memory. Then, for each pixel, the C, M, Y and K data depending on a printer color reproducibility are formed and transferred to the printer 106.

5           Next, the color noise reduction process in the image correction process unit 120 will be schematically explained.

(Color Noise Reduction Process Unit)

Fig. 3 is a block diagram schematically explaining  
10   the process of the image correction process unit 120.

In a block B1, input R, G and B signals are converted into a brightness signal Y and color difference signals Cr and Cb. Then, smoothing processes are performed to the color difference signals  
15   Cr and Cb by signal smoothing units B3 and B2 to generate color difference signals Cr' and Cb', respectively. Further, the brightness signal Y and the color difference signals Cr' and Cb' are inversely converted into R', G' and B' signals.

20           In the present embodiment, a color noise is reduced by smoothing an rapid (or abrupt) change of the color difference signal while holding the brightness signal.

Next, the operation to reduce the color noise by  
25   smoothing the rapid change of the color difference signal while holding the brightness signal will be explained.

In such a color noise reduction unit, while the brightness signal  $Y(i,j)$  is maintained, the rapid change of the color difference signal is smoothed by using a low-pass filter shown in Fig. 5 for the color difference signals  $Cr(i,j)$  and  $Cb(i,j)$ , as indicated by a following equation (5).

Fig. 5 is a diagram showing an weight configuration of the low-pass filter.

As shown in Fig. 5, by configuring the filter such that a notable (or remarkable) pixel  $(i,j)$  is surrounded by plural pixels, it is possible to perform the stable color noise reduction process irrespective of a direction of the input image. It should be noted that, in Fig. 5, the notable pixel is indicated by the pixel surrounded by a circle.

$$\tilde{f}(i,j) = \sum_{k=-2, l=-2}^{K=+2, l=+2} m(k,l) \cdot f(i+k, j+l) \quad \dots \quad (5)$$

wherein  $m(\cdot, \cdot)$  denotes the filter, and  $f(\cdot, \cdot)$  denotes the signal. It should be noted that, here,  $f(\cdot, \cdot)$  is substituted for the color difference signals  $Cr(i,j)$  and  $Cb(i,j)$ .

When the filtering process shown in the equation (5) is used as it is, the filtering process can not be performed to an image periphery edge part. At this time, as described in Japanese Patent Application No.

11-189637, it only has to perform an appropriate process for such the image periphery edge part.

In the present embodiment, the signal Y, Cr and Cb based on the NTSC (National Television System Committee) format are used. However, instead of the brightness signal, for example, the G signal from among the R, G and B signals may be used. Further, as the chromaticity signals, the signals  $Cr' = R/(R+G+B)$ ,  $Cb' = B/(R+G+B)$  and the like may be used.

Even if the noise reduction process is performed by using an  $L^*a^*b^*$  coordinate system, a  $Yxy$  coordinate system or the like, it is possible to obtain the same effect as above. Further, it is thought to perform the same process as above for an  $L^*c^*h^*$  cylindrical coordinate system, an HLS cylindrical coordinate system or the like. In this case, it is possible to perform the smoothing process after converting the coordinate values in the cylindrical coordinate system into the values in an orthogonal coordinate system.

Further, if it is enough that only color distortion has to be corrected, it is possible to perform the smoothing process to a change in hue angle. Similarly, even if the saturation is subjected to the smoothing process, it is possible to obtain the same effect as above.

$$f(i, j) \approx \tilde{f}(i, j) \quad \dots (6)$$

In another example, after executing the equation (5), as shown in the above equation (6), the value after the smoothing of the color difference signal is fed back to the side of the original image signal. By doing so, it is possible to further increase the smoothing effect.

In case of performing such a feedback process as above, as shown in Fig. 6, it is possible to use a filter in which higher weight is allocated to the processed signal value as compared with the unprocessed signal value. By doing so, it is possible to further increase the smoothing effect of the color difference signal.

Further, by configuring the weight of the filter used in Fig. 6 and the like such that its denominator becomes the power of 2, it is possible to use a shift operation mechanism of a register and thus perform a high-speed increment process.

The filter is not limited to have the  $5 \times 5$  size and to be symmetrical in the upper and lower directions and the right and left directions. Namely, if it is a filter having a low-pass filtering characteristic, it is possible to obtain the same color noise reduction effect. Of course, even if a median filter is used, it is possible to obtain the same effect as above.

Further, it is possible to suitably change a filter size according to image resolution. By changing the filter size, it is possible to obtain a stable process result irrespective of the image resolution.

5           With respect to a real space, a real-time area and a spatial frequency area, by performing a process for decreasing a high frequency component to the signals except for the brightness signal Y, it is possible to obtain the same effect as above.

10           Fig. 4 is a flow chart showing the operation of the color noise reduction process.

          The color noise reduction process is performed to the image data part in the identical image indicated by the image drawing instruction. Therefore, for example,  
15       if a graphic and an image are included in the identical image, the image part is extracted according to an analysis result of the drawing instruction, and the color noise reduction process is then performed.

          By only the color noise reduction process,  
20       apparent (or seeming) resolution might be deteriorated at an edge part of brightness and a color edge part where rapid chromaticity change is felt. Thus, in the present embodiment, edge judgment by an edge judgment unit, color edge judgment by a color edge judgment  
25       unit, edge emphasis by an edge emphasis unit and the like are added to prevent the deterioration of the apparent resolution at the color edge.



The color noise reduction process which is performed to the extracted image data will be explained in detail.

(Edge Calculation Unit)

5           In the edge calculation unit, an edge is calculated to the brightness signal Y by using, e.g., a Laplacian filter or the like, and a calculated value D\_Y is held (S1).

10           The calculated value D\_Y can be used in both the later edge judgement and the edge emphasis. If the edge emphasis is not performed, or if a high-speed unit dedicated for the edge emphasis can be used, the above value D\_Y obtained might be cancelled.

15           Though the Laplacian filter is used in the above embodiment, a passing component of a high-pass filter in the spatial frequency area can be used for the edge calculation. Further, if an animation is assumed, a difference value in the real-time area can be used to obtain the same effect as above.

20           (Edge Judgment Unit)

          In the edge judgment unit, the value D\_Y held in the edge calculation unit is compared with a threshold value TH\_Edge used for the edge judgment to judge the edge (S2).

25           It is possible to set the threshold value TH\_Edge for each process target by analyzing the histogram of the input image or the like. In this case, for

example, it is possible to prepare a frame memory storing the differentiation value of the brightness signal of the original image and thus obtain an appropriate threshold value every time by again  
5 obtaining the histogram for the frame memory storing the differentiation value, analyzing the obtained histogram with technique such as a discrimination analysis method or the like, and clustering the pixel values. Thus, a histogram calculation/analysis unit is  
10 necessary.

If judged by the edge judgment unit that the notable pixel  $f(i,j)$  is the edge, the flow advances to chromaticity change judgment (S3). Conversely, if judged that the notable pixel  $f(i,j)$  is not the edge,  
15 the flow advances to edge emphasis (S5). If the deterioration of the apparent resolution is not assumed to be a problem, it is possible to omit this edge emphasis step.

(Edge Emphasis Unit)

20 In the edge emphasis unit, the edge emphasis is performed by adding a brightness signal value  $Y(i,j)$  to the held value  $D_Y$  (S5).

Namely, the process based on an equation (1) is performed.

25 
$$Y'(i,j) = Y(i,j) + D_Y \quad \dots (1)$$

By performing the edge emphasis after or together with the color noise reduction, it is possible to

perform the edge emphasis without emphasizing color noises.

Here, speed-up and simplification of the process are achieved by performing the edge emphasis with the data obtained for the edge judgment. However, it is possible to perform the edge emphasis in other steps in the flow chart of Fig. 4.

In a case where the edge emphasis has been already performed on the side of an input apparatus, the edge emphasis need not be performed at this step.

Further, without performing the edge emphasis, it is possible to pass the data of the original image without processing it for the edge area composed of one or more pixels including the notable pixel. In this case, it is possible to perform faithful original image reproduction for the image area other than the color noise area.

(Chromaticity Change Judgment Unit)

In the chromaticity change judgment unit, a "color edge" (a rapid change part of the chromaticity) which can not be detected from the change of the brightness signal Y is detected (S3).

$$\begin{aligned}
 & D\_col\_CrL(i,j) \\
 & = | \{ Cr(i-2,j-1) + Cr(i-1,j-1) + Cr(i,j-1) \} \\
 & \quad - \{ Cr(i+2,j+1) + Cr(i+1,j+1) + Cr(i,j+1) \} | \\
 & \qquad \qquad \qquad \dots (2) \\
 & D\_col\_CrR(i,j)
 \end{aligned}$$

$$= |\{Cr(i+2,j+1) + Cr(i+1,j+1) + Cr(i,j+1)\} - \{Cr(i-2,j-1) + Cr(i-1,j-1) + Cr(i,j-1)\}| \quad \dots (3)$$

Like the above, the color edge for the Cb component is obtained.

$$D\_col(i,j) = D\_col\_CrL(i,j) + D\_col\_CrR(i,j) + D\_col\_CbL(i,j) + D\_col\_CbR(i,j) \quad \dots (4)$$

Here, the above calculated value  $D\_col(i,j)$  is compared with a threshold value  $TH\_col$  for the chromaticity change judgment, whereby the chromaticity change judgment is performed.

Though the threshold value  $TH\_col$  is fixed in the above embodiment, it is possible to calculate a feature quantity of the histogram of the input image and perform the chromaticity change judgment based on the calculated feature quantity. Further, even if the value  $D\_col(i,j)$  is calculated by using the differentiation value of the color difference signal, it is possible to obtain the similar effect. It should be noted that the automatic setting method of the threshold value  $TH\_col$  here only has to properly use the technique such as the discrimination analysis method or the like described in the above edge judgment.

Further, in the chromaticity change judgment process of the present embodiment, the color noise part



which is judged to be the edge or the color edge by the edge judgment unit or the chromaticity change judgment unit is not processed any more.

However, after such the edge judgment or the  
5 chromaticity change judgment, the junction (tie part) of the edge part and non-edge part might stand out too much.

In such a case, an edge degree  $E(i,j)$  is defined for chromaticity data  $Col(i,j)$  ( $= Cr(i,j), Cb(i,j)$ )  
10 being the process target as follows.

$$E(i,j) = D\_Y(i,j) \times H(D\_Y(i,j) - TH\_Edge) / TH\_Edge \quad \dots (7)$$

By using this, the average of the target chromaticity data and the chromaticity data after the  
15 low-pass filtering is obtained as follows.

$$\begin{aligned} Col(i,j) \\ = E(i,j) \times Col(i,j) + (1 - E(i,j)) \times Low(Col(i,j)) \end{aligned} \quad \dots (8)$$

Thus, it is possible to prevent that the junction  
20 of the edge part and non-edge part might stand out too much.

Here,  $H(\cdot)$  denotes a Heaviside step function, and  $Low(\cdot)$  denotes the low-pass filter.

(Other Judgment Unit, High Saturation Judgment Unit)

25 The color noise frequently stands out in a low-saturation area. Thus, a saturation  $S(i,j)$  ( $= \sqrt{Cr^2 + Cb^2}$ ) of the notable pixel is calculated.

Then, if the saturation  $S(i,j)$  exceeds, e.g., a threshold value  $TH\_Saturation$ , the color noise reduction process is not performed. By doing so, it is possible to perform faithful reproduction of a high-saturation part and a high-speed process.

Due to a color noise in an achromatic color (no coloring) area, it might seem that a color is being given in a part of the achromatic color area. Thus, when the notable pixel has no color, the color noise reduction process is not performed. By doing so, it is possible to perform faithful reproduction of the achromatic color area and a high-speed process.

(Modification)

In the above embodiment, the color noise reduction process is uniformly performed without any relation to whether or not the notable pixel is the color noise.

However, by performing color noise detection or color noise degree detection and then performing the color noise reduction process according to the detected color noise part or color noise degree, it is possible to further increase the effect.

As a color noise detection method, there is a method for using, e.g., a differentiation value in a chromaticity plane. Further, it is possible to provide a mode to reduce the color noise on the basis of user's manual color noise area designation.

If the color noise degree is defined by a rate

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that the process target area is the color noise, a color noise degree  $Cn(i,j)$  can be obtained by a following equation (9).

$$\begin{aligned} Cn(i,j) \\ 5 \quad &= |(\text{Col}(i,j) - \text{med}(\text{Col}(i,j)))| / (|\text{med}(\text{Col}(i,j))|) \\ &\quad \dots (9) \end{aligned}$$

wherein  $\text{med}(\cdot)$  denotes an intermediate value of chromaticity of the notable pixel and the eight pixels adjacent to the notable pixel.

10        For data of which color noise degree  $Cn(i,j)$  is high, a filter shown in Fig. 7 in which high weight is allocated to the pixels away from the notable pixel is used to perform the color noise reduction process. Thus, it is possible to obtain a higher color noise  
15        reduction effect.

Here, the target area which is used to calculate the intermediate value  $\text{med}(\cdot)$  may be an area having any shape and size if such the area includes the notable pixel. Further, even if an average value is used  
20        instead of the intermediate value  $\text{med}(\cdot)$ , it is possible to obtain the same effect as above.

[Third Embodiment]

Here, in order to avoid descriptive complexity, the same steps as those in the first embodiment are  
25        added with the same symbols and the explanation thereof will be omitted.

Fig. 8 is a flow chart showing the operation of



the color noise reduction process according to the present embodiment.

(Highlight Judgment Unit)

A hard copying apparatus such as an inkjet printer or the like adopts a method of substituting paper white as white. For this reason, a white part ( $R = G = B = 255$ ) is the paper white, but, e.g., dots are emitted onto a non-white part by the Inkjet printer. Thus, tint is similar between the above two cases, but presence of the dots might be felt discontinuous.

Fig. 14 is a diagram showing image data subjected to a filtering process with different tint for each divided area in case of dividing the image data, and an image division method.

In any case, as shown in Fig. 14, in a case where a white block 11 and a block 12 which is essentially the white block but partially includes a non-white texture exist (called a non-white block hereinafter), if the notable pixel and its peripheral pixels are smoothed by the color noise reduction process, tint might be slightly different between the white block and the non-white block. Namely, the white block is the paper white, but the dots might be emitted to the non-white block.

Thus, in the highlight judgment unit, it is judged whether or not one point is the paper white (S11). Then, the color noise reduction process is not



at the edge part of brightness and the color edge part where rapid chromaticity change is felt though brightness change is small. Thus, in the present embodiment, edge judgment by the edge judgment unit, color edge judgment by the color edge judgment unit, edge emphasis by the edge emphasis unit and the like are added to prevent the deterioration of the apparent resolution at the color edge.

(Scene Change Judgment Unit: Interlinear Color Difference Judgment Unit)

In the above embodiment, the color noise reduction process is performed by using the  $5 \times 5$  filter shown in Fig. 5.

In this configuration, the filtering process is performed to image data added with numerals 3 and 8 in Fig. 12, in the same manner as for other image process unit block. For example, in a case where image data of a scenery photograph or the like is processed, the smoothing is performed with brown of the ground and blue of the sky which are uncontinuous in the original image data. Thus, there is a room for improvement that tint of the image after the filtering process changes.

Thus, in the above embodiment, in the interlinear color different judgment unit, if an average color difference between a process-target line and a line above the process-target line by one is not equal to or smaller than a color difference threshold value

Th#ColDiff#Line, it is considered that the input image data to such an image process module as above is uncontinuous, whereby such the input image data is detected as an uncontinuous point (S12).

5           In the present embodiment, a kind of filter is changed on the basis of the positional relation between the line detected as the uncontinuous point and the target image data.

10           Figs. 9A, 9B and 9C are diagrams showing the weight configurations of the low-pass filters. Namely, Fig. 9A shows the filter for a three-line process, Fig. 9B shows the filter for a two-line process, and Fig. 9C shows the filter for a one-line process.

15           Fig. 10 is a state transition chart showing a process sequence in a case where the scene change judgment unit is provided, and the filter for processing the image is changed according to a position of the process target in the image.

20           Fig. 11 is a diagram showing how to change the filter in the case where the filter for processing the image is changed according to the position of the process target in the image.

25           As shown in Fig. 11, in the color noise reduction process, when the first line of the input image is processed, the smoothing of the color difference signal is performed by the filter of Fig. 9C with use of only the first line of the image (L1 in Fig. 11, P1 in Fig.

10). When the second line of the input image is processed, the smoothing of the color difference signal is performed by the filter of Fig. 9B with use of the second line of the image and the first line above the second line by one (L2 in Fig. 11, P2 in Fig. 10).

When the third line of the input image is processed, the smoothing is performed by the filter of Fig. 9A with use of the third line of the image, the second line above the third line by one, and the first line above the third line by two (L3 in Fig. 11, P3 in Fig. 10) (S13).

Namely, when the uncontinuous point of the input image data is detected in the interlinear color different judgment unit, as shown by symbols T21 and T31 in Fig. 10, the filtering process area is changed from the current three-line process of P3 in Fig. 10 or the two-line process of P2 in Fig. 10 to the one-line process of P1 in Fig. 10. This is called a memory refresh operation after band change judgment.

By performing the filtering process with use of such the filter structure, for example, as shown in Fig. 12, even when one image data is divided by the application and input to the image process module, it is possible to perform the appropriate filtering process. Here, numerals 1 to 10 in Fig. 12 denote a range of the image data which is divided and input to the image process module. Further, each pair of upward

and down ward arrows shown in Fig. 11 denotes a range of the image data used when the notable line indicated by a white circle is smoothed.

Further, by performing the filtering process with  
5 use of such the filter structure, the output is obtained every time the image data is input. Thus, it is possible to perform the filtering process that a delay is not caused in the image data output after the process.

10 When the average color difference is obtained, the average color difference need not necessarily be an accurate color difference. For example, it is possible to appropriately perform sampling for the ten pixels of the notable line on the image and then use the average  
15 color difference obtained for such the ten pixels. Further, it is possible to obtain the color difference by using, e.g., only the R component of the R, G and B data or only the Y component of the Y, Cr and Cb data.  
[Fourth Embodiment]

20 In the present embodiment, the process which is performed by the image correction process unit 120 in Fig. 2 when an enlargement process is performed to the input image will be concretely explained.

It should be noted that the structure of the image  
25 process apparatus is the same as explained in the above other embodiments.

The process procedures of image feature quantity

calculation, natural image judgment, image correction method determination, brightness correction, saturation correction, color noise reduction and image enlargement will be explained.

5           Each of the above image processes is performed to the image data part concerning the identical image indicated by the image drawing instruction. Therefore, for example, if a graphic and an image are included in the output image, the image part concerning the  
10 identical image is extracted, and the image process shown in Fig. 15 is performed.

          It should be noted that an image type can be discriminated by judging a kind of drawing instruction. Namely, the image is indicated by a raster data  
15 command, the graphic is indicated by a vector command, and text data is indicated by a text command.

          In the present embodiment, the processes are performed in the order shown in Fig. 15 to be able to properly obtain the color noise reduction effect.  
20 (Image Feature Quantity Calculation Unit)

          In the image feature quantity calculation unit of a step S61, as the feature quantity of the image part, on the basis of the input image data at the image part, a brightness histogram is first created, and a  
25 highlight point HL, a shadow point SD and the number of colors are calculated. Further, a saturation signal is created from the color difference signal, and an

average saturation value  $S_{ave}$  is calculated.

In the present embodiment, the saturation signal is created from the color difference signal according to an equation  $S = \sqrt{Cr^2 + Cb^2}$ .

5           Here, if the size of the process-target image is large, it is possible to obtain the image feature quantity by appropriately sampling reference points from the target image. In the present embodiment, for example, 10000 reference points are selected in the  
10   input image data of  $1600 \times 1200$  pixels, and various histograms are obtained for such the selected reference points. Here, as a reference point selection method, for example, there is a method of setting a sampling interval in the image lateral direction to  $1600 \text{Mod}(100)$   
15   pixels and a sampling interval in the image longitudinal direction to  $1200 \text{Mod}(100)$  pixels, and scanning the target image with the respective sampling intervals to obtain the image feature quantity.

It should be noted that, as the image feature  
20   quantity obtained in the step S61, it is possible to calculate another feature quantity such as a saturation histogram or the like if such the feature quantity accords to a condition used in each process later described.

25   (Natural Image Judgment Unit)

The image indicated by the raster data command includes a computer graphic or the like of which



characteristic is different from that of a natural image such as a portrait and a scenic. For example, since the computer graphic is the image created by using the application, to begin with any color noise does not exist. Further, if the later-described color noise reduction process is performed to a gradation image such as the computer graphic or the like, deterioration of coordination might occur.

Similarly, if the later-described lightness and saturation correction process is performed to the gradation image such as the computer graphic or the like, deterioration of coordination might occur in the vicinity of highlight, in the vicinity of darkness, at a high-saturation part, or the like.

Accordingly, in the present embodiment, in the natural image judgment unit of a step S62, it is judged based on the image feature quantity obtained by the image feature quantity calculation unit of the step S61 whether or not an image kind of the process-target image judged to be the image based on the drawing instruction is a natural image, and it is controlled not to perform the later-described color noise reduction process and lightness and saturation correction process to the natural image. Conversely, if judged that the image kind is not the natural image, the flow advances to a step S66.

Here, as shown in Fig. 18, the used colors tend to

be biased in an artificial gradation image such as the computer graphic or the like. Thus, the natural image judgment pays attention to this tendency and thus selects a non-natural image based on whether or not the distribution of the brightness histogram is discrete. In the present embodiment, for example, if the number of used colors calculated by the image feature quantity calculation unit of the step S61 is smaller than a threshold value Th\_Cols\_Photo, the process-target image is judged to be the non-natural image.

In the present embodiment, the pseudo number of used colors obtained from the brightness histogram is used as the number of used colors. However, for example, it is possible to use the result obtained by counting different combinations of the brightness and color difference signals.

(Image Correction Method Determination)

In the image correction method determination unit of a step S63, the image correction method in the later-described lightness and saturation correction process unit is determined for the image judged to be the natural image by the natural image judgment unit of the step S62, by using as indexed the highlight point HL and the shadow point SD obtained in the image feature quantity calculation unit of the step S61.

(Brightness Correction Method Determination)

The brightness correction method will be briefly

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Then, the above saturation emphasis process is performed to the saturation signal S, and an inverse process of the above equation is performed to convert

the saturation signal into the color difference signal.

It should be noted that it is possible to previously set the saturation emphasis process condition by a user, or to calculate the saturation emphasis process condition on the basis of the average saturation value Save.

(Color Noise Reduction Process Unit)

In the color noise reduction process unit of a step S64, the color noise reduction process as explained in the first to third embodiments is performed.

When the color noise is included in the process-target image, the color noise part might be emphasized by the brightness and saturation correction process or the later-described image enlargement process.

Further, even if the color noise reduction process is performed, the effect is not often achieved enough for the emphasized color noise part.

Thus, in the present embodiment, the color noise reduction process is first performed, and the brightness and saturation correction is performed to the image data after the noise reduction process.

As in the present embodiment, by the color noise reduction process to perform the smoothing process to color difference, there is a case where apparent resolution at the color edge part for brightness or at the color edge part where rapid chromaticity change is

felt though brightness change is small is deteriorated.  
Thus, in the present embodiment, edge judgment by the  
edge judgment unit, color edge judgment by the color  
edge judgment unit, edge emphasis by the edge emphasis  
5 unit and the like are added to prevent the  
deterioration of the apparent resolution at the color  
edge.

(Brightness and Saturation Correction Process Unit)

The brightness and saturation correction process  
10 unit of a step S65 will be explained.

As to the image data subjected to the color noise  
reduction by the color noise reduction process unit of  
the step S63, the brightness and color difference  
signals are corrected in the step S65 on the basis of  
15 the brightness correction method and the saturation  
correction method obtained in the step S63.

Further, the brightness signal is corrected based  
on the brightness correction curve obtained in the step  
S63.

20 On the other hand, as to the saturation signal, if  
judged in the step S62 that the average saturation  
value  $S_{ave}$  is smaller than the threshold value  
 $Th\_High\_Saturation$ , a process according to the  
saturation emphasis process condition set for the  
25 saturation signal is performed to the color difference  
signal.

$$Cr'' = 1.2 \times Cr'$$

$$Cb'' = 1.2 \times Cb'$$

According to the present embodiment, it is possible to perform the brightness and saturation correction process with use of the brightness signal Y and the color difference signals Cr and Cb used in the color noise reduction process unit as it is. Namely, it is possible to perform the color noise reduction process and the brightness and saturation correction process efficiently.

In the present embodiment, the lightness correction is performed based on a lookup table, and the saturation correction is performed based on simple calculation, whereby a high-speed process is achieved.

When a color palette dedicated for the image data exists, the color conversion (lightness and saturation correction) is performed to the color palette to perform the lightness and saturation correction process in the block, whereby a high-speed process is achieved. (Image Enlargement Process: Anti-Aliasing Process)

Next, an image scaling process (anti-aliasing process) in the step S66 will be explained.

When a digital camera image is printed and output by the inkjet printer, since the digital camera image is the image at monitor resolution level, it is necessary when the digital camera image is output by the inkjet printer to convert the resolution of this image into resolution by which one nozzle of an ink

emission unit is assumed to be minimum. Ordinarily,  
when the image of the digital camera of 2,000,000-pixel  
class (1600 × 1800 pixels) is output by the inkjet  
printer of about 600dpi, it is necessary to enlarge or  
5 expand the digital camera image to two or three times.

As an enlargement method, it is possible to use an  
interpolation method such as a conventionally known  
bicubic method or the like. Further, when the anti-  
aliasing is not especially needed, it is possible to  
10 use a simple enlargement method by which one pixel in  
an original image is allocated to four pixels in an  
output image.

According to the image enlargement process, the  
color noise part is similarly enlarged. On the other  
15 hand, since the filter size for the color noise  
reduction process in the present embodiment is a fixed  
size, the color noise reduction effect becomes weak.  
Thus, in the present embodiment, the image enlargement  
process is performed after the color noise reduction  
20 process was performed so as to prevent that the color  
noise is enlarged due to the image enlargement process.  
Further, as described above, the color noise can be  
satisfactorily reduced by the color noise reduction  
process.

25 Further, since points to be processed (called  
process-target points hereinafter) increases due to the  
image enlargement process, such the image enlargement

process is finally performed. By doing so, it is possible to reduce the number of color noise reduction processes and lightness and saturation correction processes, whereby an efficient process is achieved.

5           In the present embodiment, the color noise reduction process and the brightness and saturation correction process are performed to the luminance and color difference signals. Besides, such a color noise reduction process and a brightness (lightness) and  
10          saturation correction process as above can be performed to an image signal indicated by a signal representing brightness and a signal representing tint. For example, it is possible to use a CIE  $L^*a^*b^*$  system, or use the G component of R, G and B signals as the signal  
15          representing brightness and  $Cr'\Delta R/(R+G+B)$ ,  $Cb'\Delta B/(R+G+B)$  as the signal representing tint.

          Further, it is possible to use a cylindrical coordinate system such as  $L^*c^*h^*$  system, an HLS system or the like. In case of using the cylindrical  
20          coordinate system, it is possible to perform the smoothing after converting the coordinate values in the cylindrical coordinate system into the values in an orthogonal coordinate system. Further, when it is enough to correct only color distortion, it is possible  
25          to perform the smoothing to a change in hue angle.

          Further, when the edge emphasis process is premised, or when the deterioration of the apparent



resolution is not assumed to be a problem, it is possible to omit the edge judgment process and the edge emphasis process.

Further, when the process by which the "color edge" is emphasized is performed to the image after the color noise reduction process, it is possible to omit the process by the chromaticity change judgment unit.

Further, it is possible to control whether or not the color noise reduction process should be performed based on a user's manual instruction, and to control the color noise reduction process to be performed according to the result of the above judgment process. [Fifth Embodiment]

In the above fourth embodiment, it was assumed that the digital camera image is printed and output, and the case where the input image is subjected to the enlargement process was explained. However, according to circumstances, an image reduction process is performed. In such a case, since the process-target image can be reduced in size by the image reduction process, it is unnecessary to perform the process at the end. Namely, it is possible to perform the image reduction process, the color noise reduction process, and then the lightness and saturation correction.

As above, when a scaling rate of the input image has been previously known, it is possible to adaptively determine the order of the image scaling process and

other image processes according to this scaling rate, whereby a more efficient image process can be achieved.

Further, when the output image is small, it is necessary to perform a thinning process to the input  
5 image. In the thinning process, when the thinning is performed by interpolation with use of the signal values of the peripheral pixels around the notable pixel, the tint of the image after the reduction process might be different due to the color noise on  
10 the image. In such a case, in consideration of quality of the output image, it is desirable to perform the color noise reduction process, the image reduction process, and finally the lightness and saturation correction.

15 However, when the output image is small, the color noise on the image is unremarkable. Thus, when the output image size is smaller than a predetermined size, the color noise reduction process need not be performed.

20 As above, in case attaching importance to the quality of the output image, it is desirable to determine the order of the image processes on the basis of the scaling rate of the image scaling process, the size of the output image, and the scaling method. It  
25 should be noted that, even if all of the above three conditions are not considered but only one condition is considered to control the order of the image processes,

it is possible to obtain the similar effect.

[Sixth Embodiment]

The sixth embodiment of the present invention will be explained with reference to Fig. 16. Hereinafter,  
5 in order to avoid explanatory complexity, the explanation of the same steps as those in the above embodiments will be omitted, and process procedures will be briefly described.

On the basis of the feature quantity obtained by  
10 the image feature quantity calculation unit of a step S71, it is judged in a step S72 whether or not the target image is the natural image. Then, in a step S73, the color noise reduction process is performed to the image judged to be the natural image.

15 Further, the image feature quantity for the image data of which color noise has been reduced is again calculated by the image feature quantity calculation unit of a step S74. Then, by using the again-calculated image feature quantity, the lightness and  
20 saturation correction method is determined by the image correction method determination unit of a step S75.

Since the color noise is easily generated in a low-lightness part, it is possible that the shadow point SD shifts from the essential shadow point.  
25 However, by processing the image according to the process procedure of the present embodiment, it is possible to perform the image correction process with

use of the more accurate shadow point SD, whereby it is possible to obtain a suitable processed result.

[Seventh Embodiment]

5       The seventh embodiment of the present invention will be explained with reference to Fig. 17. Hereinafter, in order to avoid explanatory complexity, the explanation of the same steps as those in the above embodiments will be omitted, and process procedures will be briefly described.

10       In the seventh embodiment, when the image correction process is not performed for the non-natural image, it is possible to omit the image feature quantity calculation unit of the step S71 and the natural image judgment unit of the step S72.

15       For example, when it is possible to previously discriminate the natural image data from the non-natural image data such as the computer graphic or the like on the side of the printer driver 103 shown in Fig. 2, it is possible to omit the above units.

20       [Other Embodiments]

      In the present invention, program codes themselves for causing an apparatus or system connected to various devices to operate them to achieve the functions of the above embodiments, and a means such as a storage medium storing the program codes for supplying the program codes to a computer constitute the present invention.

      As the storage medium storing the program codes,

for example, a floppy disk, a hard disk, an optical disk, a magnetooptical disk, a CD-ROM, a magnetic tape, a nonvolatile memory card, a ROM, or the like can be used.

5           It is needless to say that the present invention includes not only the case where the functions of the above embodiments are achieved by executing the supplied program codes with the computer, but also a case where the functions of the above embodiments are  
10       achieved by executing the program codes with an OS (operating system) running on the computer or cooperation of the OS and other applications or the like.

          Further, it is needless to say that the present  
15       invention includes a case where the supplied program codes are once stored in a memory provided in a function expansion board inserted in the computer or a function expansion unit connected to the computer, and then a CPU or the like provided in the function  
20       expansion board or the function expansion unit performs all or a part of the actual processes based on instructions of the program codes, whereby the functions of the above embodiments are achieved by such the processes.

25       Further, it is possible to appropriately combine the above plural embodiments.

          Although the present invention has been explained

with the preferred embodiments, the present invention is not limited to them. Namely, it is obvious that various modifications and changes are possible in the present invention without departing from the spirit and scope of the appended claims.

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